

Applying Registry Services to Spaceflight Technologies to Aid in the Assignment of Assigned Numbers to Disparate Systems and their Technologies to further enable Interoperability

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I. Abstract

To date very little effort has been made to provide interoperability between various space agency projects. To effectively get to the Moon and beyond systems must interoperate. To provide interoperability, standardization and registries of various technologies will be required. These registries will be created as they relate to space flight. With the new NASA Moon/Mars initiative, a requirement to standardize and control the naming conventions of very disparate systems and technologies is emerging. The need to provide numbering to the many processes, schemas, vehicles, robots, space suits and technologies (e.g. versions), to name a few, in the highly complex Constellation initiative is imperative. The number of corporations, developer personnel, system interfaces, people interfaces will require standardization and registries on a scale not currently envisioned. It would only take one exception (stove piped system development) to weaken, if not, destroy interoperability.

To start, a standardized registry process must be defined that allows many differing engineers, organizations and operators the ability to easily access disparate registry information across numerous technological and scientific disciplines. Once registries are standardized the need to provide registry support in terms of setup and operations, resolution of conflicts between registries and other issues will need to be addressed. Registries should not be confused with repositories. No end user data is "stored" in a registry nor is it a configuration control system.

Once a registry standard is created and approved, the technologies that should be registered must be identified and prioritized. In this paper, we will identify and define a registry process that is compatible with the Constellation initiative and other non related space activities and organizations. We will then identify and define the various technologies that should use a registry to provide interoperability. The first set of technologies will be those that are currently in need of expansion namely the assignment of satellite designations and the process which controls assignments. Second, we will analyze the technologies currently standardized under the Consultative Committee for Space Data Systems (CCSDS) banner. Third, we will analyze the current CCSDS working group and Birds of a Feather (BoF) activities to ascertain registry requirements. Lastly, we will identify technologies that are either currently under the auspices of another standards body or technologies that are currently not standardized. For activities one through three, we will provide the analysis by either discipline or technology with rationale, identification and brief description of requirements and precedence. For activity four, we will provide a list of current standards bodies e.g. IETF and a list of potential candidates.

II. Introduction

The scope and dynamics of space operations are changing. With the announcement that the USA will return to the Moon and eventually to Mars, a new dynamics in space systems and operations is emerging. New information based technologies are evolving that will change how we use Information Technology (IT) in future space operations. As the Internet evolved, it became clear that registries like the Internet Assigned Number Authority (IANA) were necessary to control and provide access to those users, developers and others, who were developing the technologies and the users who needed the information that traveled on it. What has made the Internet functional is the fact that it is interoperable. All anyone has to do is plug his device into a network and, regardless of the functionality of the device; it can communicate to virtually anywhere. The only way to accomplish this type of interoperability and control was to establish the IANA registry. This approach over time has proven to

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be effective. Now as we contemplate what will be required to return to the Moon and on to Mars, questions arise concerning current and future technologies that will be required to enable interoperability and what mechanisms will be necessary to control them. We know from past experience, that there will be a significant requirement to insure unique numbering of space vehicles, satellites, robots and bases. We, the space flight community, must identify and implement interoperability and control policies and processes including access methodologies. These must be conducive to developer, manager and the general user populations. This conduciveness must be in terms of process, ease of access and understanding (lack of complexity). If interoperability is to succeed, it must be understood and implemented at all levels. From the highest managers (for policy) to procurement/acquisition personnel (to ensure what is bought is interoperable), to the engineers and technicians (who will design and install) and finally to the operational personnel (who will operate and maintain this system of systems end to end). To accomplish this interoperability some sort of registry process will be required. The scope of registry services described in this paper is generally applied to the technologies used in space-based development, systems (terrestrial and extraterrestrial) and operations. Technologies that are under an established registry e.g. IANA for the Internet, that may have application to space systems will be included.

However, first within the space operations community there must be a single point for defining and standardizing registries. The definitions of the registries, how to organize and operate them, and how they interrelate must be focused within one recognized authority. Multiple registries of the same technologies would not enable interoperability but would discourage it, making unique numbering difficult if not impossible. Imagine the chaos of employing two independent registries for assigning spacecraft IDs that use the same or integrated transport mechanisms!

In this paper we will recommend an approach to resolve this situation. We will list and briefly describe; the technologies currently being used publicly and within the space community that are already supported by a registry e.g. the Spacecraft Identifier, the CCSDS operational standards to ascertain applicability to registries, within the current CCSDS working groups potential areas where registry services could be applied. We will look at publicly available technologies that may be applied to future space based systems not currently used in space systems.

III. Interoperability

A simple definition for interoperability from a dictionary.com website states that interoperability is the ability of software and hardware on multiple machines from multiple vendors to communicate. Taking the definition a little further and putting it in terms of the current problem, one can think of interoperability as the ability of having multiple systems of different types to exchange and use resources and information with little or no prior knowledge of each other's systems. Interoperability problems might not be a big concern in a small environment with a single control center or remote investigator site, but as future space operations grow and span across many different elements, it is easy to see how quickly interoperability could become an issue. One way to attack this problem is to require each control center to be designed exactly the same way. This would insure interoperability between the control centers but it may be a hard sell to the overall user community that may have a different design concept for their control center. Aside from hurting innovation, this may also be viewed as a hostile form of network dictatorship. A better approach to this problem would involve registering the control center data interface. This would allow anyone in the user community to search the registry to see how the control center data interface is defined. Now the remote user has the freedom to design his or her control center however they want without having to know the full design behind the original control center. Registries would play a key role in helping define the interfaces between these elements and could eventually take the place of Interface Control Documents (ICD) that are used to define how an element will need to design its interface to be able to communicate between elements. This would eliminate the need for multiple documents with each center, international entity, and remote investigator or developer community member.

IV. Define the Problem

Currently there are no standards or processes to manage and control spaceflight related technologies. Granted there are many registries and standards organizations that exist to address specific areas but these areas are not related to spaceflight. To enable interoperability one aspect for success will be the ability to access specific standards and controls during design, implementation and operations.

Unique numbering will be required in all facets of space based operations ranging from frame identification associated with specific spacecraft, proximity communications between spacecraft and between ground elements and spacecraft. These unique number requirements will range from spacecraft identification, applications, processes

to individual information schemas e.g. XML. Within the space operations community since its inception, each project or program generally developed all the necessary systems specifically for their use (fulfilling their specific requirements) without recognizing that interoperability between disparate systems and operations would be necessary. Until the Space Station was implemented this was not a serious concern especially when using expendable vehicles. Today with shrinking budgets, it is beneficial to reuse hardware and software, to be able to develop and interact with other systems and applications without significant knowledge of those systems and applications, and do so in very short time frames e.g. minutes, hours or days.

Specifically, how registries could help with future space operations is in the management of Space Craft Identifiers (SCID). A SCID is an eight to ten bit binary field that is tied to the link layer protocol and helps identify which telemetry stream is associated with a particular spacecraft or spacecraft subsystem. There will be an increasing amount of hardware and vehicles being flown in support of manned and unmanned missions to explore our solar system. A redesigned SCID registry could take control of this assignment authority and help manage the need to assign these SCID and eliminate the need to reclaim them for reuse after a mission is over. There could be safety and operational issues associated with reuse of previously assigned numbers, if numbering of specific schemas, applications and processes is involved.

Specifically, unique number of space vehicles, rovers, satellites, robots, space suits will be required well beyond what can be numbered under the present numbering scheme. As Table 1 indicates under the internationally recognized CCSDS the number of SCIDs ranges from 256 to 1024 numbers with approximately one half of these assigned to existing spacecraft. This leaves approximately 500 unique numbers unassigned. While the process allows reassignment of numbers after a program has ended, it is estimated by the authors that only 250 or so numbers are available for assignment to any major effort to return to the Moon and on to Mars. There are estimates that more than 60,000 unique assignments will be required for spacecraft IDs to go to the Moon and on to Mars. These assignments may be required for transport over RF systems, for assigning unique application numbers and for assigning and registering XML schemas.

Also some technologies have a large scale impact as far as implementation is concerned. New technologies are continually being introduced and current technologies are continually evolving. Without a registry to help keep track of these evolving technologies, developers could be wasting a lot of time reinventing solutions to problems that other developers have already solved. This situation cannot continue into the future because going back to the Moon and then on to Mars will require significant interoperability at the hardware, software, service and operational levels. Currently with some minor exceptions there are no specifications, mechanisms, processes or guidelines in place that can enable this type of interoperability. A few examples of technologies that could benefit from a registry will be covered in a different section of this paper.

Address	TM Space Data Link Protocol	TC Space Data Link Protocol	AOS Space Data Link Protocol	Proximity-1 Space Link Protocol
Transfer Frame Version Number (TFVN)	Always 1 (binary encoded number is 00)	Always 1 (binary encoded number is 00)	Always 2 (binary encoded number is 01)	Always 3 (binary encoded number is 10)
Spacecraft Identifier (SCID)	0 to 1023	0 to 1023	0 to 255	0 to 1023
Virtual Channel Identifier (VCID)	0 to 7	0 to 63	0 to 63	0, 1
Multiplexer Access Point Identifier (MAP ID)	N/A	0 to 63	N/A	N/A
Port Identifier	N/A	N/A	N/A	0 to 7

Table 1, CCSDS Space Link Protocol Unique Identifiers by Protocol⁴

V. The Solution

The CCSDS is an international organization made up of most space agencies world wide. The CCSDS is mandated to provide standards under the International Organization for Standardization. Figure 2 shows the CCSDS organization chart, and the list of member and observers agencies and organizations is in Appendix A. Under the CCSDS charter, the Space Assigned Numbers Authority (SANA) is to provide unique numbering to the space operations community. Figure 1 provides a breakdown of the SANA. Within CCSDS it states in section 4.1.3.6 **Space Assigned Numbers Authority (SANA)** “The core registrar for the CMC’s activities is the SANA. Many space mission protocols require that someone keep track of key protocol numbering assignments that were added after the protocol came out. Typical examples of the kinds of registries needed are for SCIDs, protocol version numbers, reserved Application Process Identifiers, and Standard Formatted Data Units (SFDU) Control Authorities. The SANA provides this key configuration management service for CCSDS. The CCSDS Management Council (CMC) approves the organization that will act as the SANA. Its public interface is focused through Web-based services provided by the Secretariat.”

Space	=	Space flight activities (flight and ground)
Assigned	=	Registry(ies)
Numbers	=	Numbering scheme(s)
Authority	=	Controlling processes and organizations

Figure 1, the Space Assigned Numbers Authority Definition Overview

The “Space” in SANA indicates the scope of the SANA which includes spaceflight activities both on the ground and in flight. There are many types of spacecraft and their integrated technologies that could possibly be provided unique numbers. The scope of SANA is all spaceflight activities that cross international boundaries. Included would be existing public registries that are applicable to spaceflight that could be approached to assign/manage

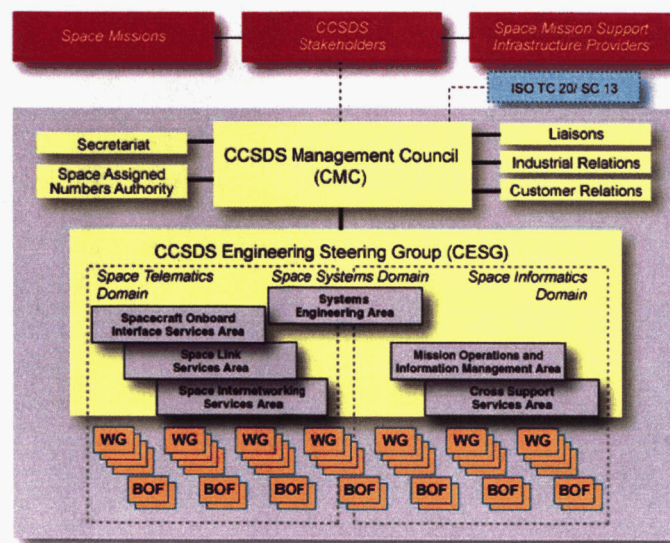


Figure 2, CCSDS Organizational Structure⁵

unique numbering of spaceflight activities under their established purview. The SANA would provide the standards and mechanisms to identify and standardize registries that would assign unique numbering to various aspects of spaceflight activities including but not limited to Earth based centers and remote terrestrial locations, vehicles, space objects, robots, satellites and bases (manned and unmanned, small and large) and potentially systems, applications and processes. The SANA should address public registries that support spaceflight e.g. IANA. A registry process may register ownership of hardware, formats, numbers software applications, XML schemas, especially where they cross system, program and/or national boundaries.

The "Assigned" in SANA requires a mechanism to provide numbering and infers a registry process of some sort. Numbering can be assigned by a registering process in a hierarchical registry of registries that assigns standardized control and process to the registry processes and its contents. It could assign and recognize ownership to the sub-registry process and identify ownership and control that can be publicized. A registry process could provide the registration process for numbers associated with very general or very detailed level of specifics, objective associations, e.g. spacecraft (stuff you can kick) and subjective type associations, e.g. XML schemas (stuff you cannot kick).

The "Numbers" in SANA, refers to a standardized numbering scheme for all unique identification numbering approaches. The SANA needs to address various spaceflight activities that require numbering, operational situations that affect numbering, e.g. when two registered independent objects are mated, and other situations like age, use, conflicts and efficiencies e.g. number abbreviations, standards for formats, and schemas. The SANA must accomplish all of this while avoiding conflicts in numbering schemes throughout the space community.

Finally, the "Authority" in SANA, is who is in control and by what authorization for each registry. A Registry of Registries (RoR) is required to accomplish this implementation that will provide a single point for registry standardization and control. Figure 3 depicts how a RoR and the sub-registries would be related. A standard for the RoR and sub-registries would be established and the standards would apply to all sub-registries as guidelines. Also, individual sub-registry control authority would be resident in the "registered owner" of the sub-registry. The control authority for the RoR would be the CCSDS, and for sub-registries the individual agencies, programs/projects under which the sub-registry is registered. Sub-registries may be as simple as a pointer to another registry and a standardized control authority (CA) much like the CA in place today, but adjusted for the anticipated increased volume and technical diversity. Where necessary, an adjustment to the CA guidelines for specific sub-registries may be required.

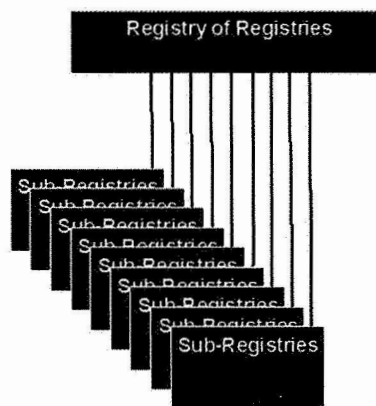


Figure 3, Registry of Registries layout

The RoR is a concept of a place to define ownership, control and access. Access to registry information is critical for interoperability where access by implementers, operators and managers is crucial. Therefore it must be able to conduct indexing of many registries and potentially pointing to the repositories associated with those registries. Under a RoR a centralized control point would be established for multiple participants to access and locate information and resources, which will provide dynamic resource integration. Having a registry of registries is necessary and essential to accomplish this. A goal is to have an entry portal into a registry of registries, which will be the single, authoritative access point to all other registries. The registry of registries would allow for a conducive

search across the whole scope of registries. Figure 4 shows the registry of registries layout depicting a split between space organizations and public sector registry organizations. The top block in the RoR would act as the portal into the registry of registries and the sub registries below. Below the RoR, embedded in sub-registries, would be registries for any number of registered technologies such as the SCID, interface control definitions and XML schemas.

As Figure 5 depicts, Spacecraft IDs and its control authority would be controlled as it is today by CCSDS, but through a newly defined approach and process. Potentially a new approach to numbering based on future requirements should be developed. Through the CCSDS standards development process new numbering and control authority approaches and procedures could be developed.

Between the RoR and the sub-registries, a process for coordination, control and problem resolution will be required as depicted in Figure 6. There will undoubtedly be coordination needed between the RoR and sub-registries in instances of defining scopes, procedures and contacts. Control issues will be resolved through this process. Any problems arising during implementation and operations will need to be resolved. As shown, two existing registry requirements are XML schemas and asynchronous messaging.

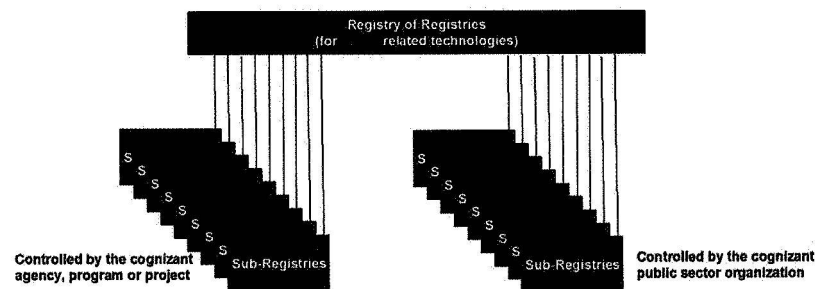


Figure 4, Registry of Registries Breakdown by Space Organizations and the Public Sector

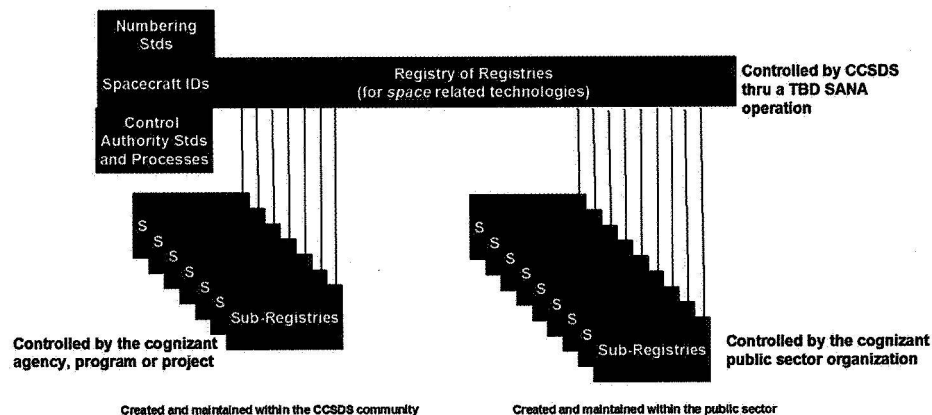


Figure 5, Registry of Registries Spacecraft IDs and Control Authority

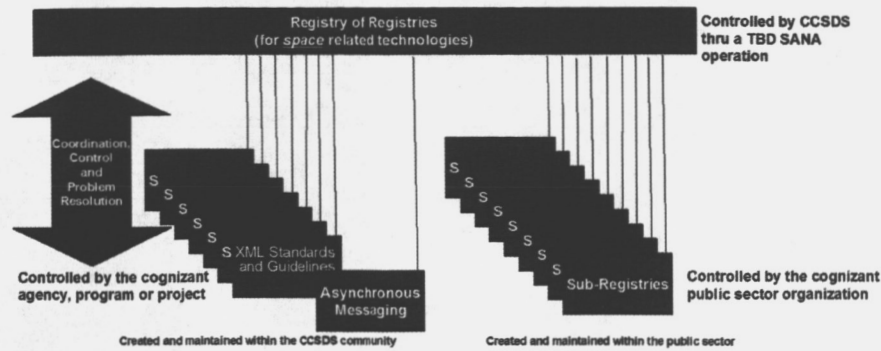


Figure 6, Registry of Registries Process and Examples

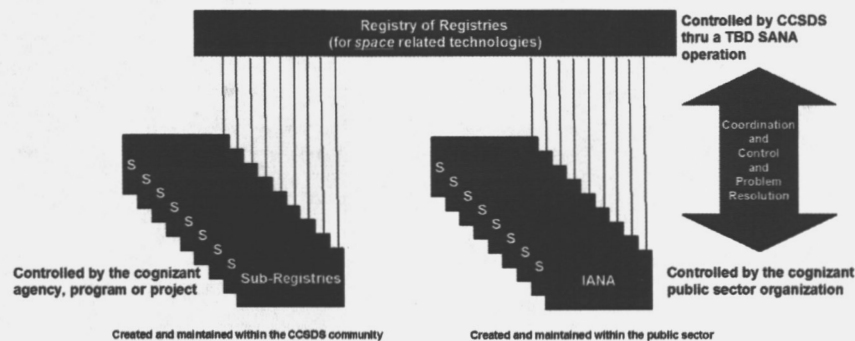


Figure 7, the Public Sector Depiction

VI. What to Register

The question always arises concerning what to register when we discuss registries. Generally speaking, technologies that have a common and broad application across agencies, systems, applications, technologies and domains may benefit from a registry. This is especially true when they need unique identification. This will include technologies or systems that have multiple agencies and contractors involved in development. There are four categories, which need to be either investigated for registry requirements or assessed for possible adjustment. These categories follow the CCSDS organization process since CCSDS is the only international standards body dealing with space data transport. The four categories are:

Category one (1) is current CCSDS registries, namely SCIDs and SFDU CA.

Category two (2) is the set of protocol identifiers, assigned numbers, port numbers and reserved APIDs that are currently documented within CCSDS approved documents and SCPS protocol numbers including other current deployments like SLE service providers. This would include existing elements e.g. glossary, ground data systems and acronym lists.

Category three (3) is the list of current CCSDS working groups e.g. SM&C, XML schema and namespaces, and birds of a feather that may require registries and also includes current CCSDS developments.

Category four (4) is the catch all for all other activities which may possess a registries requirement, e.g. information models, reference software, but currently do not fall under CCSDS and/or do not currently operate under a registry.

The technologies in these categories will be looked at a little closer in this section. One item that may not seem to have much significant impact but tends to be a big problem at NASA is the use and reuse of acronyms. A registry of acronyms would help prevent a project from using an acronym that is already in use. This would ensure proper communication between different projects and or centers by ensuring that acronyms are indeed unique. As discussed earlier the SANA registry could take control of a redesigned SCIDs registry to help enforce SCID distributions. Message Bus software would be another technology to consider for a registry. This would handle the types of messages published on the message bus. A developer could then make use of the registry to see which messages that their application could subscribe or publish to the message bus. The IANA could designate a large

group of IP addresses for the SANA to maintain for spaceflight use or IANA could manage them for SANA. It is easy to see as the deep space network evolves and more elements such as satellites, repeaters, spacecraft elements are added to the network that IP addresses will need to be assigned to this growing number of elements. A registry would be a good way for a user to see what IP address is assigned to a specific element that he/she needs to communicate with. With Ipv6 on the horizon this will become even more important for a registry to control these new IP addresses for space elements. XML schema, which addresses certain commands or telemetry, could be kept in a registry. Users wanting to develop tools to make use of these types of commands and telemetry would be able to access the registry and see what format of XML schema to use. This would make interoperability much easier since all users would be required to use the same schema for certain commands and telemetry. Without this type of registry there would be no easy way to prevent multiple users from developing their own unique XML schemas for the same telemetry and commands making interoperability between tools much less certain.

VII. Registry Information Access

There must be easy access by operations and development personnel to registry information. Obviously current technology is adequate to facilitate broad access. Depending on the technology and the responsible registry authority, it is anticipated that access will be via a single authoritative access point which either possess the information or points to it. It should be pointed out that the registries described in this paper will not contain user data e.g. act as a repository or archive. There can be many implementations for the access but one that holds promise is to create a portal for entry into a registry of registries. From this portal all registered information with regards to space operations would be available. Across the top tabs of the portal would be the disciplines for instance ground control systems – commanding management, telemetry management. If a user chooses command management then all associated registry information would be presented. Along the side would be lists of services available to the specific choice made in this case Command Management. These services could range from those available to anyone like voice and video conferencing to very discipline specific authoritative information like navigation registries. One of the main benefits is that everything presented in the portal is authoritative. The ideal setup is to configure a registry of registries that will allow one to be able to locate, get details about, and make use of any resource located in our registry through structured metadata. In this registry configuration, there will be four important components: a full searchable registry, local searchable registry, local publishing registry, and a registry of registries. Of course, standards and protocols must be defined so that different registry services will be able to interoperate. Therefore, the architecture and organization of the registry must allow all others to have access. Two important standards that will help define the registry are interface specification and XML schemas. The interface specification is the agreement amongst different parties for defining the search interface. XML schemas formally define the various resource types and allow incoming and outgoing messages to be automatically verified for correctness of content and structure. XML and its related technologies will be a great choice for protocol. Not only is XML a standard way of formatting information, but it also provides XML parsers, namespaces and schemas. Registry commands will provide an interface to manage the registry files. Our registry setup does not have to be a Service Oriented Architecture (SOA)-based service registry. But a SOA can provide some advantages. SOAs are frameworks for reusability.

VIII. Management and Control

Overall management and control of the registry process should not be resident in any single national entity but should be controlled with broad international involvement. Currently there is only one organization that traverses and involves most civilian national space agencies. This is the CCSDS. This organization has been in existence for well over 25 years. It has a management structure that enables involvement on the international level. Figure 1 above shows the organizational structure of CCSDS and a list of member and observer agencies are in Appendix A.

The CCSDS uses working groups staffed by personnel from the various member agencies. Birds of a Feather (BoFs) are precursors to working groups. A BoF defines the charter, estimated resources and schedule for a working group. After the CESG and CMC review, and if approved, then a working group is formed. The subject, as the list indicates, varies widely. **Appendix B lists the current CCSDS working groups and birds of a feather.**

IX. Conclusion

The SANA will provide a registry service that will greatly enhance current and future space operations. The amount of services that will be needed to get back to the Moon and eventually Mars will be very extensive. The SANA will provide a means to register these services and control the use of these services.

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X. Appendix A, List of CCSDS Member and Observer Organizations⁶

Member Agencies

- Agenzia Spaziale Italiana (ASI)/Italy.
- British National Space Centre (BNSC)/United Kingdom.
- Canadian Space Agency (CSA)/Canada.
- Centre National d'Etudes Spatiales (CNES)/France.
- Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)/Germany.
- European Space Agency (ESA)/Europe.
- Russian Federal Space Agency (FSA)/Russian Federation.
- Instituto Nacional de Pesquisas Espaciais (INPE)/Brazil.
- Japan Aerospace Exploration Agency (JAXA)/Japan
- National Aeronautics and Space Administration (NASA)/USA.

Observer Agencies

- Austrian Space Agency (ASA)/Austria.
 - Central Research Institute of Machine Building (TsNIIMash)/Russian Federation.
 - Centro Tecnico Aeroespacial (CTA)/Brazil.
 - Chinese Academy of Space Technology (CAST)/China.
 - Commonwealth Scientific and Industrial Research Organization (CSIRO)/Australia.
 - Communications Research Laboratory (CRL)/Japan.
 - Danish Space Research Institute (DSRI)/Denmark.
 - European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)/Europe.
 - European Telecommunications Satellite Organization (EUTELSAT)/Europe.
 - Federal Service of Scientific, Technical & Cultural Affairs (FSST&CA)/Belgium.
 - Hellenic National Space Committee (HNSC)/Greece.
 - Indian Space Research Organization (ISRO)/India.
 - Institute of Space and Astronautical Science (ISAS)/Japan.
 - Institute of Space Research (IKI)/Russian Federation.
 - KFKI Research Institute for Particle & Nuclear Physics (KFKI)/Hungary.
 - MIKOMTEK: CSIR (CSIR)/Republic of South Africa.
 - Korea Aerospace Research Institute (KARI)/Korea.
 - Ministry of Communications (MOC)/Israel.
 - National Oceanic & Atmospheric Administration (NOAA)/USA.
 - National Space Program Office (NSPO)/Taipei.
 - Space and Upper Atmosphere Research Commission (SUPARCO)/Pakistan.
 - Swedish Space Corporation (SSC)/Sweden.
 - United States Geological Survey (USGS)/USA
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XI. Appendix B, List of CCSDS Working Groups (WG) and Birds of a Feather (BoFs)⁷

System Architecture WG
Information Architecture WG
Security WG
Space Assigned Numbers Authority WG
Space/Ground Interoperability Architecture BoF
XML Standards & Guidelines SIG
Delta-DOR SIG
Data Archive Ingestion WG
Navigation WG
Information packaging & Registries WG
Spacecraft Monitoring and Control WG
Reference Model & Concept WG
Service Management WG
Cross Support Transfer Service WG
Onboard Bus LAN WG
Time Critical Onboard Network Services WG
Time Critical Onboard Application Services WG
Onboard Plug and Play BoF
Onboard Transducer System BoF
Wireless BoF
RF Modulation WG
Space Link Coding and Synchronization WG
Data Compression WG
Space Link Protocols WG
Telecommand Channel Coding WG
Ranging WG
Proximity-1, Build-2 WG
High Rate Uplink WG
Long Erasure Codes BoF
CFDP Interoperability Testing WG
Packet Protocol WG
Cislunar WG
Asynchronous Message Service WG
IP over CCSDS Space Links WG
Mars Communication Profile BoF

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Agenda

- ◆ Introduction
- ◆ Interoperability
- ◆ Define the Problem
- ◆ The Solution
- ◆ Conclusion

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Spaceops PRESENTATION

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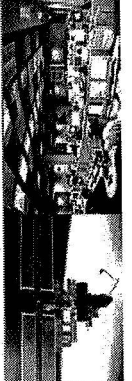


Introduction

Spaceops PRESENTATION

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Introduction

- ◆ Scope and dynamics of spaceflight are changing
 - ◆ Announcement that NASA will return to the Moon
 - ◆ Then eventually on to Mars
- ◆ Old method: stove pipe systems
 - ◆ Not a big problem when the project was small
 - ◆ Future space ops will involve multiple vehicle, control centers, etc.
- ◆ New method: interoperable systems especially at the data level
- ◆ For this to succeed it must be understood an implemented at all levels
 - ◆ Manager
 - ◆ Procurement
 - ◆ Engineering
 - ◆ Operations personnel

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Spaceops PRESENTATION

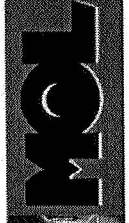
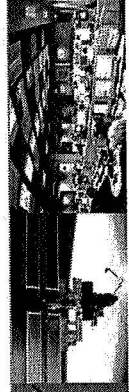


Interoperability

- ◆ Interoperability as it applies to spaceflight systems
- ◆ Author's definition: The ability to communicate without any or little reconfiguration, design or development at the network, systems, application and process levels and without significant (or any) need to understand their internal workings
- ◆ Why?
 - ◆ Decrease development costs
 - ◆ Decrease operational costs
 - ◆ Ability to respond more efficiently to problems
 - ◆ Enable extensibility, availability, upgradeability, evolve-ability...

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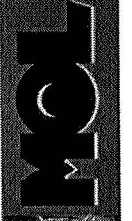


Define the Problem

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Define the Problem

- ◆ Interoperability is required to go back to the Moon and on to Mars especially if the NASA Constellation Program goes international without the mechanisms in place to enable it (no more stove piping of systems and their functions)
- ◆ Systems cannot interoperate if there are no universal numbering schemes to prevent miscommunications, confusion and for safety
- ◆ Future technologies, to be widely accepted and used in spaceflight systems, will require unique numbering for extensive use in multi-dimensional spaceflight systems e.g. XML/UML schemas, messaging transport
- ◆ Future spaceflight operations will include numerous vehicles, satellites, rovers, robots, bases, etc. (estimated at 60,000+)
 - ◆ Requiring unique numbering for transport management and within applications, data and processes
- ◆ No central international management and control is in place to accomplish this and neither at the agency level
- ◆ As an example of the numbering limitations, the current CCSDS Spacecraft Identifier numbering scheme for CCSDS frame id is limited to 1024 vehicles with approximately half in use

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Current CCSDS Space Data Link Protocol

Table 3-1: Addressing Capability of Space Data Link Protocols

Address	TM Space Data Link Protocol	TC Space Data Link Protocol	AOS Space Data Link Protocol	Proximity-1 Space Link Protocol
Transfer Frame Version Number (TFVN)	Always 1 (binary encoded number is 00)	Always 1 (binary encoded number is 00)	Always 2 (binary encoded number is 01)	Always 3 (binary encoded number is 10)
Spacecraft Identifier (SCID)	0 to 1023	0 to 1023	0 to 255	0 to 1023
Virtual Channel Identifier (VCID)	0 to 7	0 to 63	0 to 63	0, 1
Multiplexer Access Point Identifier (MAP ID)	N/A	0 to 63	N/A	N/A
Port Identifier	N/A	N/A	N/A	0 to 7

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Define the Solution

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Define the Solution

- ◆ Establish a central standardized registry of registries for spaceflight activities
 - ◆ To register registries that are technology specific
 - ◆ To establish ownership, control and recognition
 - ◆ To enable multiple unique numbering schemes
 - ◆ To control the registry process
 - ◆ To maintain coordination and problem resolution between various registries and their controlling authorities
 - ◆ Provide procedures for the standardized registry process
 - ◆ Enable a single point of access to all registry activity
 - ◆ Provide a single point of reference for developers, implementers, operators and management
- ◆ Establish sub-registries for various technologies that require unique numbering and control
 - ◆ Assigns and recognizes sub-registry ownership and control
 - ◆ Provide and assign control authority specifically addressing the requirements of the specific technology

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Define the Solution

- ◆ Organize the Registry of Registries (RoR) under the Consultative Committee for Space Data Systems (CCSDS)
 - ◆ Recognized international organization chartered under ISO13?? in operation for over 25 years
 - ◆ Within the CCSDS Charter is the Space Assigned Numbers Authority (SANA):
- ◆ Procedures Manual for the Consultative Committee for Space Data Systems CCSDS, A00.0-Y-9 Yellow Book, para. 4.1.3.6 Space Assigned Numbers Authority (SANA) states:

“The core registrar for the CMC’s activities is the SANA. Many space mission protocols require that someone keep track of key protocol numbering assignments that were added after the protocol came out. Typical examples of the kinds of registries needed are for Spacecraft IDs, protocol version numbers, reserved APIDs, and SFDU Control Authorities. The SANA provides this key configuration management service for CCSDS. The CMC approves the organization that will act as the SANA. Its public interface is focused through Web-based services provided by the Secretariat.”

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General Definition of Registries

WRT Space Systems and Operations and What They are Not

- ◆ Webster - a: an official record book **b** : an entry in a registry
 - ◆ Register of: do not call numbers, internet numbers, spacecraft....
- ◆ What are registries as they relate to space based flight technologies
 - ◆ Where uniqueness is required
 - ◆ Where ownership, control and recognition is needed
 - ◆ Register official information, concerning specific technologies and applications e.g. Spacecraft Ids
 - ◆ Information that crosses organizational, international and technological boundaries
 - ◆ Official record book: Registry of Registries and “sub-registries”
 - ◆ Entry in a registry: the assigned number
 - ◆ Can/should enable uniqueness
 - ◆ Provide authority and control over a specific aspect of a technology as related to spaceflight
 - ◆ Assigns a numbering scheme to maintain uniqueness, authority and control
 - ◆ Accessible by many with adequate security
- ◆ And What They are Not
 - ◆ Electronic services registries embedded in a digital architecture of some kind e.g. a service registry associated with Service Oriented Architecture
 - ◆ Not applicable to closed loop systems, applications or functions
 - ◆ Not configuration management
 - ◆ Not a catalog, warehouse or repository
 - ◆ Not an archive, holds no user data

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What is SANA

Space = Space flight activities (flight and ground)

Assigned = Registry(ies)

Numbers = Numbering scheme(s)

Authority = Controlling processes and organizations

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What are Space Assigned Numbers?

- ◆ What is a unique identifier: a string of alpha/numeric and/or bit level identifiers assigned through a registering process to make what is being registered unique (not duplicative) that does not change over time
- ◆ Assigned to:
 - ◆ Spacecraft, robots, centers/bases, space suits.....
 - ◆ Common (across spacecraft/ground systems etc) applications, processes and functions
- ◆ How will they be used in real time ops and over time
 - ◆ Stream identifier
 - ✦ Telemetry, voice, video and commands
 - ◆ Data identifier for recording and archiving
 - ◆ Identify specific XML schemas, messages
 - ◆ Identify specific application functions within a spacecraft

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Space Assigned Numbers Authority

- ◆ Scope: Various aspects of spaceflight activities including but not limited to Earth based centers and remote terrestrial locations, vehicles, space objects, robots, satellites and bases (manned and unmanned, small and large) and potentially systems, applications and processes
- ◆ Addresses public activities that may support spaceflight e.g. IANA
- ◆ Register ownership of hardware, formats, software applications, XML schemas
 - ◆ Especially where they cross system, program and/or national boundaries

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Space Assigned Numbers Authority

- ◆ How: Assigned by a registering process
- ◆ Assigns and recognizes ownership to the sub-registry process
- ◆ Identifies ownership that can be publicized
- ◆ Assigns standardized control and process to the registry and its contents
- ◆ Register
 - ◆ By numbers associated with a TBD level of specifics
 - ◆ Objective associations, e.g. heat sensor (stuff you can kick)
 - ◆ Subjective type associations, e.g. services, functions (stuff you cannot kick)

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Space Assigned Numbers Authority

- ◆ What: Standardized numbering scheme for all numbering (unique identification) approaches
 - ◆ Needs to address:
 - ✦ Various spaceflight activities that require unique numbering
 - ✦ Operational situations that affect numbering e.g. when two registered independent objects are mated
 - ✦ Address other situations age, use, conflicts and efficiencies e.g. number abbreviations
 - ✦ Standards for formats, schemas
 - ✦ Avoiding conflicts in numbering schemes throughout the space community

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Space Assigned Numbers Authority

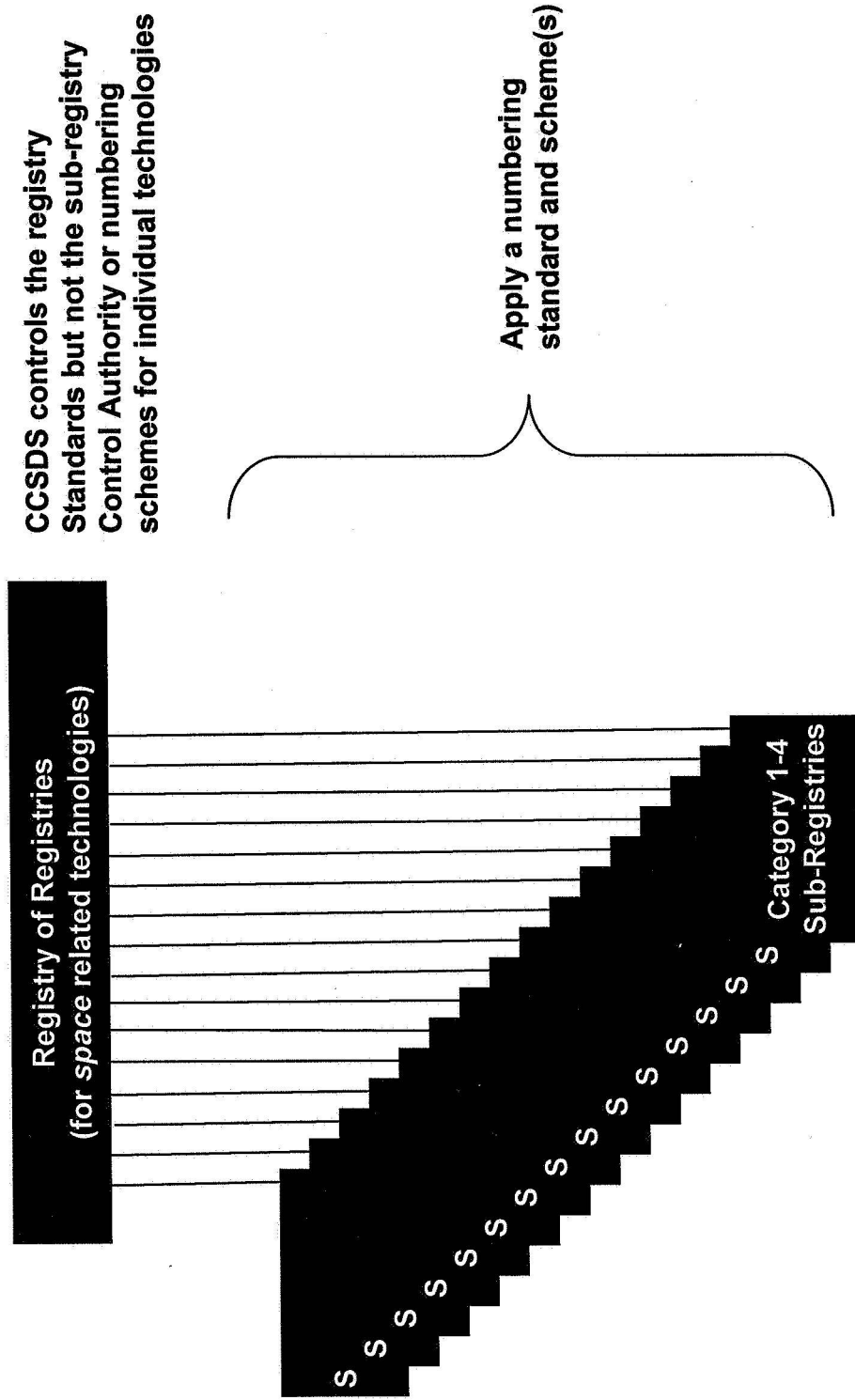
- ◆ The authority is who is in control and by what authorization
- ◆ Implementation is a Registry of Registries (RoR) that is standard and the standards apply to all sub-registries as guidelines within the RoR
- ◆ Individual sub-registry control authority is resident in the “registered owner” of the registry
 - ◆ For the RoR – CCSDS
 - ◆ For sub-registries – individual agencies, programs/projects other public registries e.g. IANA
 - ◆ Sub-registries may be as simple as a pointer to another registry
- ◆ Standardized “control authority” much like the CCSDS CA in place today, but adjusted for the increased volume and diversity

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Overall Description

Standard(s) required: for creating, maintaining, controlling and operating the RoR and sub-registries

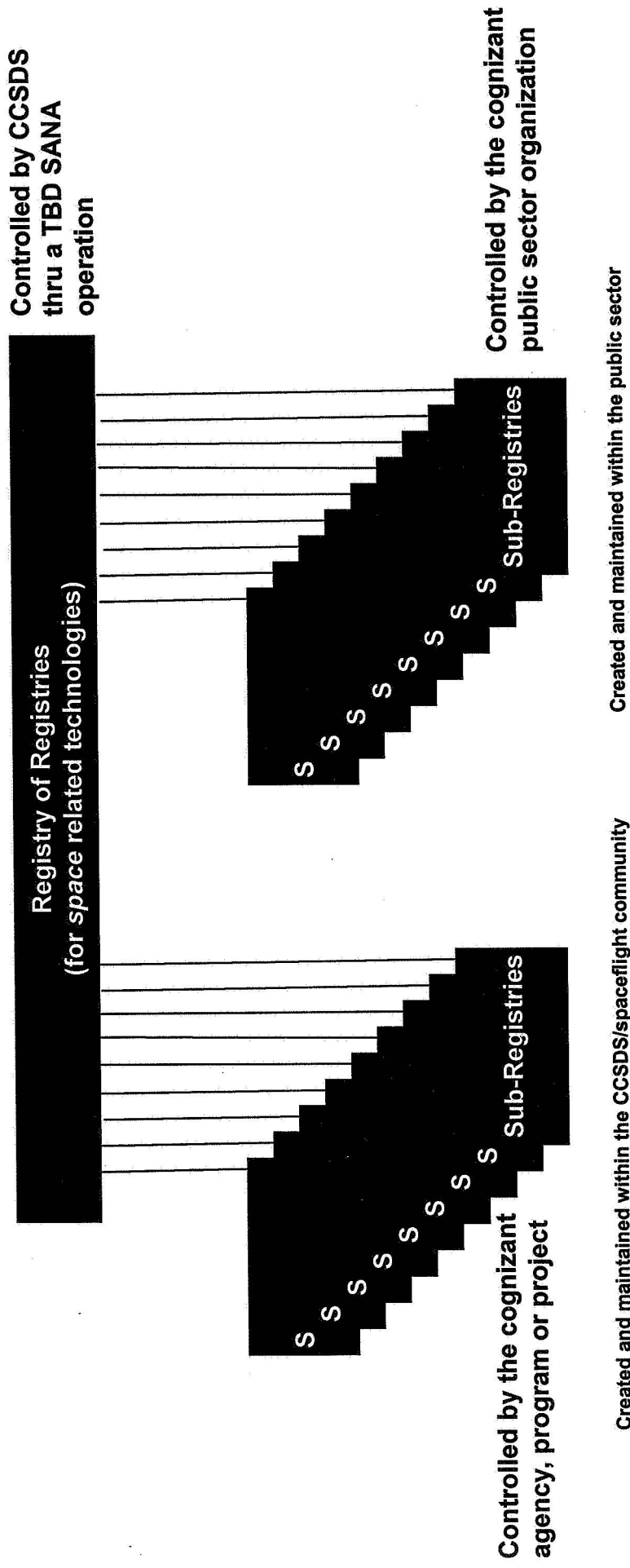


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Categories of Ownership, Maintenance and Control

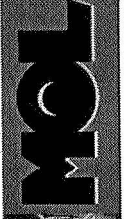
A sub-registry is a standalone registry registered with the RoR



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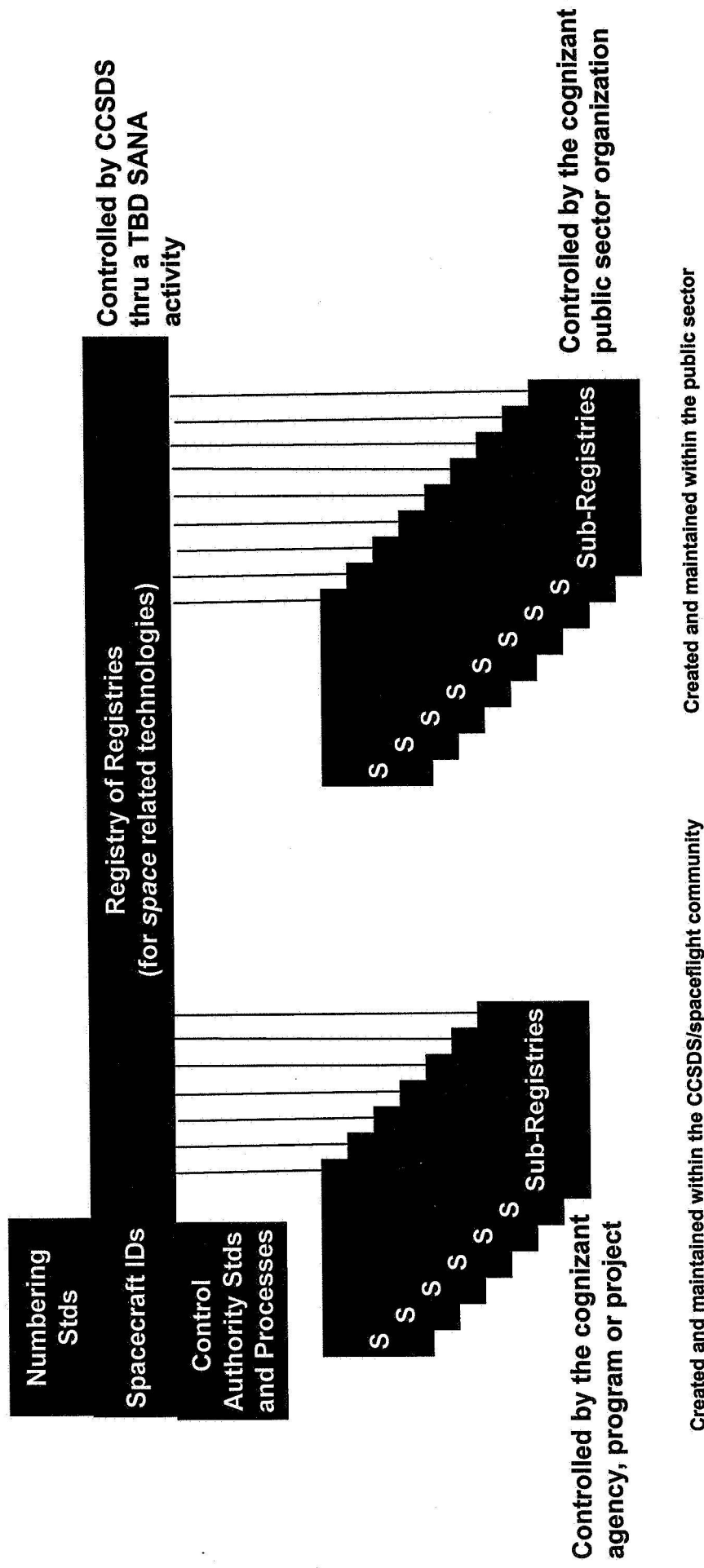
Four Categories to be considered for registries

- ◆ Category 1: Current CCSDS Registries and control authorities
- ◆ Category 2: The set of protocol identifiers, assigned numbers, port numbers and reserved APIDs that are currently documented within CCSDS approved documents and SCPS protocol numbers including other current deployments like SLE service providers.
- ◆ Category 3: The list of current CCSDS working groups e.g. SM&C, XML schema and namespaces, and birds of a feather that may require registries and also includes current CCSDS developments.
- ◆ Category 4: The catch all for all other activities which may possess a registries requirement, e.g. information models, reference software, but currently do not fall under CCSDS and/or do not currently operate under a registry

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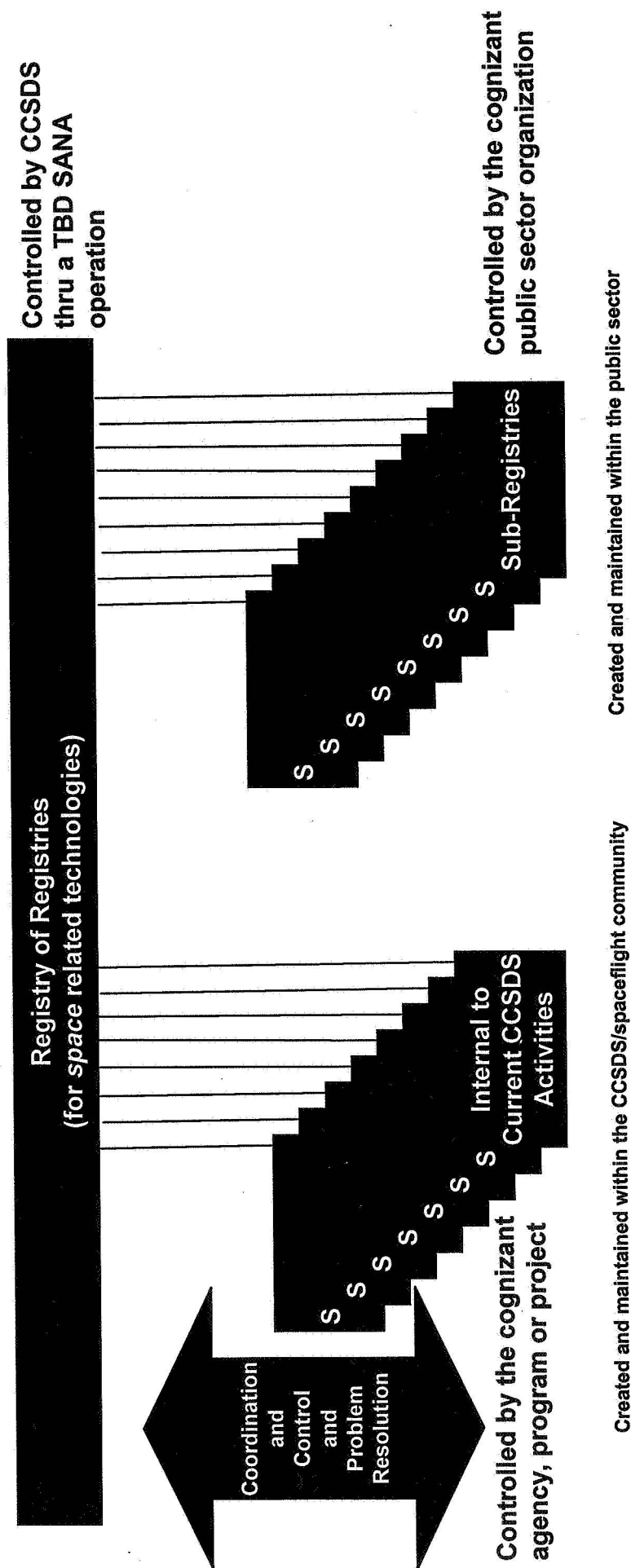
Category One Example



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Category Two Example



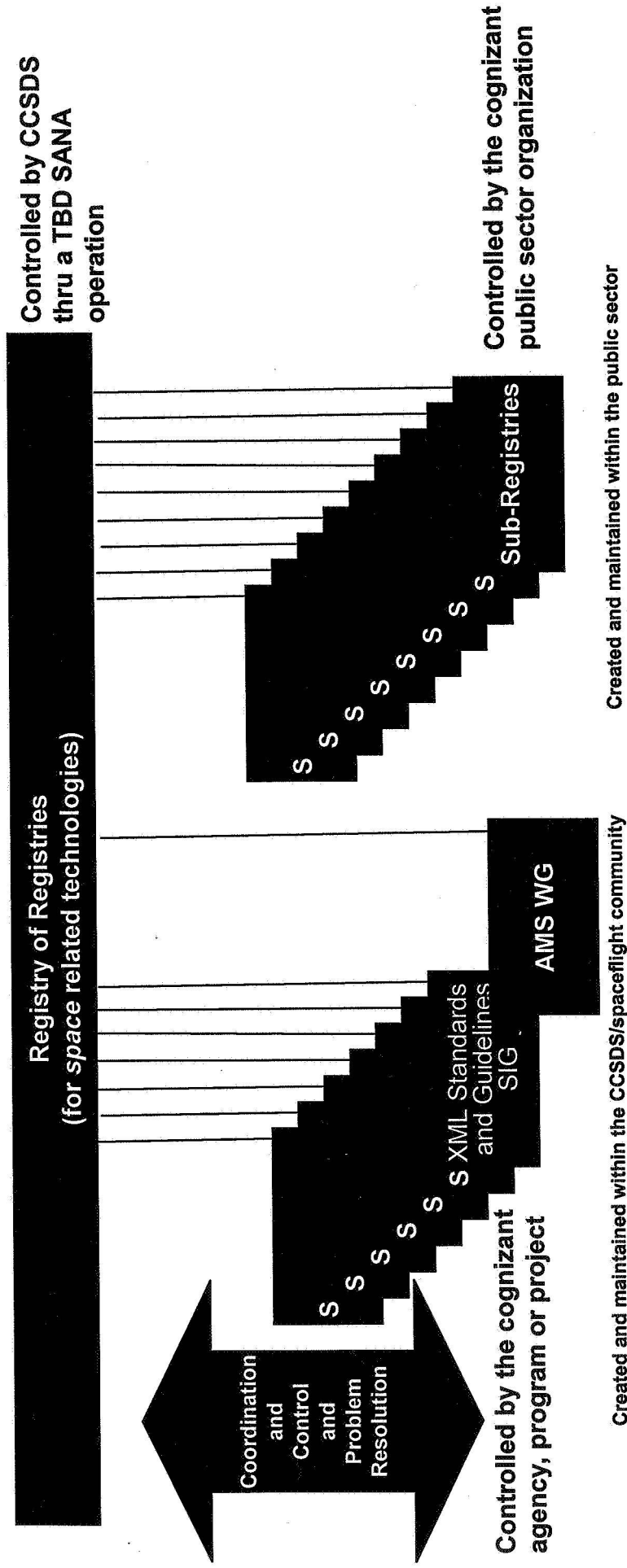
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Category Three Example



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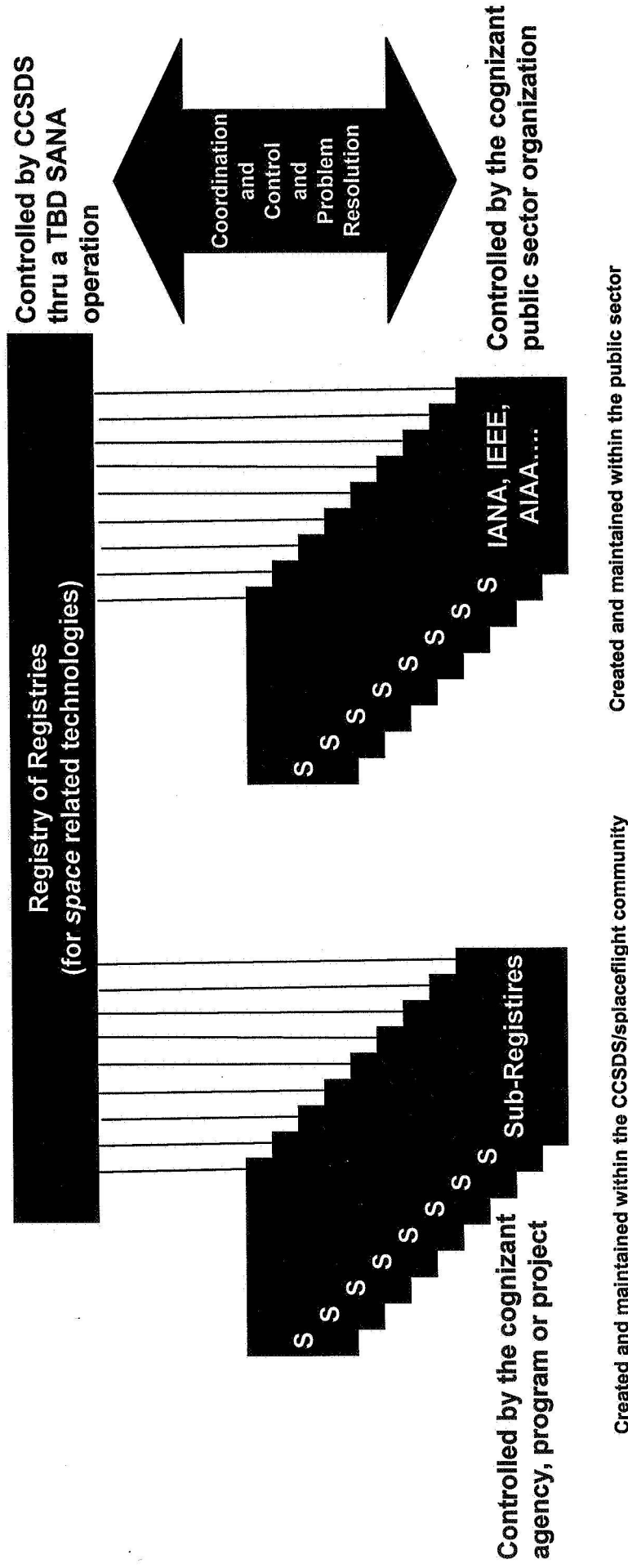
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MOL



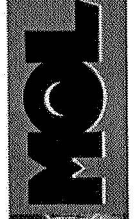
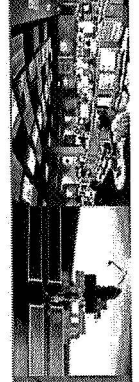
Category Four Example



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Conclusion

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Conclusions

- ◆ Implement a Registry of Registries under CCSDS
- ◆ Define the requirements for a RoR
- ◆ Identify technologies that may require unique numbering
 - ◆ Spacecraft Identification Numbering
 - ◆ XML schemas
 - ◆ Information models
 - ◆ Message bus entities
 - ◆ Protocol versions
 - ◆ Port assignments

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Conclusion

Invite participants to the SANA WG

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